Enclosure 3

Team Member ~~Alternate Recommendations~~Dissenting Opinions

1. Proposal to use 2~~1~~5 knots crosswind in Lateral Directional Takeoff Conditions [FAA, DGAC, ALPA]

The team has discussed at great length the levels used to determine jam positions and generally settled on flight conditions somewhat larger than typically used in past certifications. However, this is not the case when considering the 15 knot crosswind levels used in the proposal. The strictly numerical approach would simply "AND" the probability of a crosswind and the probability of a jam in a short exposure time. There is evidence to say that jam failures do not necessarily occur in a purely probabilistic fashion. They may occur as a result of external events or be connected to maneuvering or specific positioning of the controls. For this reason, the determination of "normally encountered position" should be conservative and give careful consideration to pilot recommendations regarding conditions regularly seen in-service. Use of 25 knots crosswind in the determination of lateral/directional jams better reflects in-service experience.

The use of 25 knots is also consistent with the existing AC 25.1309 guidance for use of probabilities described in paragraph 8.e, "A probability of 1 should usually be used for encountering a discrete condition for which the airplane is designed," and "When combining the probability of such a random condition with that of a system failure, care should be taken to ensure that the condition and the system failure are independent of one another...."

The 1 in 1000 flights criteria in this proposed advisory circular describes the intent of the conditions to be covered. The value of a 25 knot crosswind as representing a 1 in 1000 occurrence is consistent with both AC 25-7 and AC 20-57A.

To be added in Section 9(b) of Draft B following:

(1) Jammed Lateral Control Positions.

(i) Takeoff: The lateral control position for wings-level at V_1 in a steady crosswind of the lesser of 2~~1~~5 knots (at a height of 10 meters above the takeoff surface) or the maximum demonstrated crosswind. **Variations in wind speed from a 10 meter height can be obtained using the following relationship:**

$$V_{alt} = V_{10meters} * (H_{desired}/10.0)^{1/7}$$

Where:

$V_{10meters}$	=	**Wind speed at 10 meters AGL (knots)**
V_{alt}	=	**Wind speed at desired altitude (knots)**
$H_{desired}$	=	**Desired altitude for which wind speed is sought**

(Meters AGL), but not lower than 1.5m (5 ft)

(ii) In-flight: The lateral control position to sustain a 12 deg/sec steady roll rate from $1.23V_{SR1}(1.3V_S)$ to V_{MO}/M_{MO} or V_{fe}, as appropriate, but not greater than 50% of the control input.

Note: If the flight control system augments the pilot's input, then the maximum surface deflection to achieve the above maneuvers should be considered.

(2) Jammed Longitudinal Control Positions.

(i) Takeoff: Three longitudinal control positions should be considered:

(1) Any control position from that which the controls naturally assume without pilot input at the start of the takeoff roll to that which occurs at V_1 using the manufacturer's recommended procedures.

Note: It may not be necessary to consider this case if it can be demonstrated that the pilot is aware of the jam before reaching V_1 (for example, through a manufacturer's recommended AFM procedure).

(2) The longitudinal control position at V_1 based on the manufacturers recommended procedures including consideration for any runway condition for which the aircraft is approved to operate.

(3) Using the manufacturers recommended procedures, the peak longitudinal control position to achieve a steady aircraft pitch rate of the lesser of 5 deg/sec or the pitch rate necessary to achieve the speed used for all-engines-operating initial climb procedures (V_2+XX) at 35 ft.

(ii) In-flight: The maximum longitudinal control position is the greater of :

(1) The longitudinal control position required to achieve steady state normal accelerations from 0.8g to 1.3g at speeds from $1.23V_{SR1}(1.3V_S)$ to V_{MO}/M_{MO} or $V_{fe,}$ as appropriate.

(2) The peak longitudinal control position commanded by the autopilot and/or stability augmentation system in response to atmospheric discrete vertical gust defined by 15 fps from sea level to 20,000 ft.

(3) Jammed Directional Control Positions.

(i) Takeoff: The directional control position for takeoff at V_1 in a steady crosswind of the lesser of 2~~1~~5 knots (at a height of 10 meters above the takeoff surface) or the maximum demonstrated crosswind. Variations in wind speed from a height of 10 meters can be obtained using the following relationship:

$$V_{alt} = V_{10meters} * (H_{desired}/10.0)^{1/7}$$

Where:	$V_{10meters}$ =	Wind speed at 10 meters AGL (knots)
	V_{alt} =	Wind speed at desired altitude (knots)
	$H_{desired}$ =	Desired altitude for which wind speed is sought

(Meters AGL), but not lower than 1.5m (5 ft)

(ii) In-flight: The directional control position is the greater of:

(1) The peak directional control position commanded by the autopilot and/or stability augmentation system in response to atmospheric discrete lateral gust defined by 15 fps from sea level to 20,000 ft.

(2) Maximum rudder angle required for lateral/directional trim from $1.23V_{SR1}(1.3V_S)$ to the maximum all engines operating airspeed in level flight with climb power, but not to exceed V_{MO}/M_{MO} or V_{fe} as appropriate. While more commonly a characteristic of propeller aircraft, this addresses any lateral/directional asymmetry that can occur in flight with symmetric power.

Replace the Note in Section 9(e)(1)(iv) ~~of Draft B~~ with:

Note: For the case of control surface jams during takeoff that are detected by the flight crew, it may be assumed that the aircraft is returned to a suitable runway, including consideration of crosswind. As a result, it can be assumed that the aircraft is returned to a runway with a favorable crosswind no more than 15 knots less than the crosswind at the time of the jam.

Response to Proposal: The proposal above to determine jammed roll and yaw control positions used during demonstration of continued safe flight and landing, would establish a crosswind level for a jam occurring during takeoff as the lesser of 25 knots or maximum demonstrated crosswind. The FAA Generic Issue Paper for flight control mechanical jam conditions and jam Issue Papers being used for current FAA certification programs establish roll and yaw control jam positions to be considered as that required for takeoff in a steady crosswind up to 15 knots. Transport Canada has indicated that recent Canadian certification programs have used a 14 knot crosswind to determine control positions for jams occurring during takeoff. The determination is based on crosswinds up to 15 knots for the following reasons:

- *The group has not identified a safety issue with the current means of compliance, which establishes a crosswind of 15 knots for determination of normally encountered roll and yaw control jam positions. An increase in crosswind to the lesser of 25 knots or maximum demonstrated capability is unwarranted.*

- *The probability of a mechanical control jam occurring between V_1 and lift-off is Extremely Improbable by numerical evaluation. ($1x10^{-7}$/flt-hr jam failure rate with less than a 5 sec. or 0.0014 hr. exposure time results in a $1.4x10^{-10}$ probability of jam during this critical period per flight.) The released FAA Flight Test Guide AC25-7A, Appendix 7 defines the probability of encountering a crosswind up to 25 knots as 1 in 1000 flights. Therefore, the probability of encountering a crosswind of 25 knots on the same flight as a mechanical control jam which occurs during the critical 5 second time period during takeoff is approximately $1x10^{-12}$ to $1x10^{-13}$.*

- *If the 25 knot crosswind criterion were adopted, more complicated control systems may be required to ensure that continued safe flight and landing characteristics are provided. For example, an aileron-only lateral control system may no longer be certificable, multiple rudder panels may be necessary, and redundant means for lateral trim may be necessary. These complications to proven control surface configurations would have a negative impact on the viability of new aircraft and may have a negative overall impact on airplane safety.*

2. Proposal to allow use of a handling qualities rating method acceptable to the certification authority in lieu of the criteria in this advisory material. [Boeing]

It is recommended that other handling qualities rating methods such as presented in Appendix 7 to AC 25-7 be allowed as alternate means of compliance for demonstrating continued safe flight and landing if it is agreeable to the certification authority. The proposed advisory material uses arbitrary static control capability and does not account for measures of control including dynamic stability or capability for controlling flight path to accomplish a specific task(eg. glide path control). The process in AC 25-7 is consistent with the principles of analysis in 25.1309, addresses both transient conditions and continued flight, and provides an orderly approach to evaluating handling qualities after failures. It has also been used successfully on previous certification programs. In prior certification efforts, airplanes have been determined to have enough maneuvering capability for continued safe flight and landing at maneuvering levels below that defined in the 25.671 proposed advisory material. It is proposed that a statement be included at the beginning of Section 9.e of the advisory material that allows the use of other handling quality rating methods that are agreeable to the certification authority.

Response to Proposal: ***Use of the other handling qualities rating methods has been discussed during team development of criteria for continued safe flight and landing. Since there is not a harmonized method accepted by all the certification agencies, criteria were developed which were generally agreeable to the team as a whole.***

<u>*Enclosure 3*</u>

3. Proposal to clarify the definition of single failure to allow consideration of the probability of subsequent fault propagation. [Bombardier, Boeing]

The following change is recommended to the single failure definition:

5. <u>DEFINITIONS</u>

q. <u>Single Failure :</u> A single failure includes any set of failures or effects that are certain to occur as a direct consequence of the initial failure.

<u>9. EVALUATION OF CONTROL SYSTEM FAILURES – 25.671(C)</u>

Subparagraph (c)(1) requires the evaluation of any single failure, excluding the types of jams addressed in subparagraph (c)(3). Subparagraph (c)(1) requires that any single failure be considered, suggesting that an alternative means of controlling the airplane or an alternative control path be provided in the case of failure of a single component, part or element of a system. All single failures must be considered, even if they can be shown to be extremely improbable. Any failure condition or effects that are certain to occur as a direct consequence of a single failure must be considered. Cascading failures or collateral damages that are not certain to occur in connection with an initial single failure, need not be considered under subparagraph (c)(1), instead such combination of events must be shown to comply with subparagraph (c)(2). Failure containment should be provided by the system design to limit propagation of the effect of any single failure to preclude catastrophic failure conditions. In addition, there must be no common cause failure that could affect both the single component, part or element, and its failure containment provisions. Failure containment techniques available to establish independence may include partitioning, separation, and isolation.

While single failures must normally be assumed to occur, there are cases where it is obvious that, from a realistic and practical viewpoint, any knowledgeable, experienced person, would unequivocally conclude that a failure mode simply would not occur, unless it is associated with a wholly unrelated failure condition that would itself be catastrophic. Once identified and accepted, such cases need not be considered failures in the context of FAR/JAR 25.671(c)(1). For example, with simply loaded static elements, any single failure mode resulting from fatigue fracture can be assumed to be prevented if this element is shown to meet the damage tolerance requirements of FAR/JAR 25.571.

<u>Rationale</u>

Since the proposed new wording deletes the reference to AC/AMJ 25.1309, the above is a repeat of AC/AMJ 25.1309 except for the underlined paragraphs.

This recommendation is based on the following:

AC/AMJ 25.1309 does not provide a definition of single failure. It does describe single failure considerations in section 11 Assessment of failure condition probabilities and analysis, but a real definition is lacking. Since 25.671 has a specific requirement addressing single failures, it should also provide a definition of single failure in the AC/AMJ 25.671.

The words used in AC/AMJ 25.1309 to describe single failure considerations; "A single failure includes any set of failures which cannot be shown to be independent from each other" are too all encompassing. Using this description, one could be asked to include all cascading effects or collateral damages regardless of how remote the combined probability of these effects or damages and the single failure is.

There is precedence for limiting the effects that need to be considered to those that are certain to occur as a direct consequence from a single failure. For example, the Boeing 777 Special Condition A-9 "Reliance on Retained Stiffness with Dual Hydraulic Actuators In stead of Mass Balance" provided the following definition: "Multiple failures will be considered as a single failure if they are certain to occur as a direct consequence of a single event". The implication here is that if the effects were not certain to occur as a direct consequence of a single event, they were considered as multiple failures. This interpretation was followed throughout the certification of the 777 Flight Control System.

If the probability of the cascading failures or collateral damages is high the combined probability would not satisfy the proposed FAR/JAR 25.671(c)(2). In particular, the second part of (c)(2), less than 1 in 1000 probability, would be very difficult to meet for likely effects. Obviously, if the numerical probability analysis shows that the combined probability is not extremely improbable, the applicant must show that the combination is not catastrophic.

Response to Proposal: The team did not choose to include a definition for single failure. The advisory material currently points to the 25.1309 use of "single failure". The team recognizes the shortcomings of how the term is used in 25.1309 but generally feels it is conservative and still allows use of engineering judgement in determining "independence".

4. Proposed revision to "continued safe flight and landing" criteria. [Transport Canada]

It is noted that para 9(e)(1)(ii) Transient Response applies to all flight control failures not shown to be extremely improbable including jams. The appropriate level of response for these failures should be no greater than the hazardous category and it is not reasonable to attempt to define a boundary right at the limit of being catastrophic. The hazardous level is consistent with the criteria originally proposed in the Transport Canada guidance material, which was tabled at the first Working Group meeting.

Transport Canada concedes that the hazardous criteria of the draft ACJ 25.1329 which was used as a basis in the working group discussions is not entirely appropriate to the flight control failure case, and proposes the following wording for para 9(e)(1)(ii):

".......For this purpose, continued safe flight and landing is defined as not encountering any one of the following:

(1) Exceedence of Limit loads

(2) Stall

(3) Speeds greater than Vdf/Mdf

(4) Buffet or vibration severe enough to interfere with control of the airplane or to cause structural damage

(5) Bank angles in excess of 67 degrees flaps up and 60 degrees flaps down

(6) Pitch angles greater than +30 degrees or lower than -20 degrees."

Response to Proposal: In developing the 25.671 criteria for safe flight and landing, the team recognized that there was an area of compliance to 25.1309 that was not specifically being addressed. That is, if a jam with a probability of 1E-06 occurred, to be consistent with 25.1309, the effects should not be Hazardous. This is an area not specifically covered by the 25.671 advisory material. The general view of the team was if a system is designed to achieve continued safe flight and landing (not Catastrophic) at the large deflections we have defined, it is likely that more probable jams at lesser deflections would have correspondingly less effect and also be acceptable.

5. Proposed revision to landing exposure criteria. [Raytheon, Cessna]

The proposed change to 25.671(c)(3) for flight control jams excludes from consideration the time immediately prior to landing. The background and intent of this exclusion should be clearly stated in the preamble to the NPRM. However, the reasons for this exclusion raise similar issues of compliance with the proposed 25.671(c)(1) for single mechanical flight control disconnects. Expansion of the landing exclusion to include single mechanical flight control system disconnects covered by 25.671(c)(1), should be considered by the FCHWG and coordinated with other committees involved in the harmonization of other affected regulations and advisory material. A possible revision to the rule could be:

"25.671(d) Mechanical flight control system disconnects considered under (c)(1) and jams considered under (c)(3) need not be assumed to occur immediately prior to landing during a reasonable time necessary for the crew to recognize the failure, react and recover."

Response to Proposal: The team recognized the similarity of some disconnect failure modes to the jam scenarios at low altitude for which an exclusion was defined. However, it was generally felt that allowing an exclusion for all disconnect failure modes in a short exposure time before landing was far too broad a criteria and that there were more feasible options to deal with disconnects than with jam failures. Addressing areas other than jams in such a unique fashion also generates a conflict *with 25.1309, which the team had accepted as a basic analysis approach for all failure conditions except jamming.*